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1 August 1960

MEMORANDUM FOR : Deputy Chief, Development Branch, DDC
SUBJECT : Monitoring of Airframe, ADC, and SAS
Systems for OXCART Vehicle

1. The purpose of this memorandum is to keep you informed of some of the technical problems that seem to warrant close attention in the OXCART program. These "areas of concern" have been discussed with the individual contractors, but no action has been taken to request additional study, design, and/or changes due to my status as a monitor in these programs. Some recommended courses of action are included at the end of this report.

2. CALIBRATED vs EQUIVALENT AIRSPEED: A large difference of opinion exists between IAC and me as to the proper airspeed that establishes the aircraft structural limit and hence, the primary pilot reference. In my discussion of this with [redacted] a rough graph was presented showing that the structural limit, expressed in terms of equivalent airspeed, does change with altitude. Thus, if a speed limit is imposed on the aircraft less than the design limit, the pilot can use one speed indication and need not worry about structural failure in this respect. This speed limit, however, when expressed in terms of equivalent airspeed at some relatively high altitude, restricts the use of full performance capability envelope for all lesser altitudes. If, in fact, the aircraft structural limits are a function of equivalent airspeed, we must accept this performance loss or give the pilot a complex climb and descent airspeed schedule. However, Volume I, AFM Flight Test Manual, states in part, "Calibrated airspeed is of interest because it provides the pilot with a measure of dynamic pressure, q_0 , on which, above all, depend the high speed structural problems." This airspeed does provide the pilot with a structural limitation that is independent of altitude and further allows for operation within the full performance-structural envelope. Lockheed further states that it is not possible to accurately measure calibrated airspeed behind the shock wave at high Mach numbers due to the inability to properly locate the static source, and hence we must use equivalent airspeed. However, the method to be used by the Honeywell Air Data Computer is to measure this same calibrated airspeed, compare it with pressure altitude, and then through a mechanical logarithmic cam, present

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USAF review(s) completed.

Approved For Release 2003/10/07 : CIA-RDP81B00879R001000020172-3

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equivalent airspeed. This, then, is supposed to provide an accurate airspeed by measuring an inaccurate airspeed and comparing it with a static pressure taken from static port that cannot be properly located. The method required to provide equivalent airspeed necessitates further complication to the ADC system. This is not in keeping with the philosophy of simple, fail-safe systems. If, in fact, this equivalent airspeed is the necessary parameter, we will have to accept the additional complexity of the ADC system and the added H-II cost of [redacted] for engineering and [redacted] for each unit. Contrary to the cable [redacted] equivalent airspeed is not supplied to the INS. The ADC supplies only static pressure to the guidance system. I do not believe that equivalent airspeed is a necessary parameter.

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3. STABILITY AUGMENTATION: The design of the SAS appears well in hand to satisfy the LAC requirements based on presently available data. The basic problem confronting H-II is the lack of data and the change in data as more wind tunnel and aerodynamic studies are completed. A serious stability and control problem does exist between 0.4 and 1.8 Mach number at 35,000 feet (formerly the estimate was from 0.8 to 1.4). The latest change in data now predicts a possible serious pitch instability at Mach 3.2 as angle of attack is increased. All work so far has been based on stability and control derivatives for the rigid airplane. No data is available to compensate for mere and/or thermal elasticity. H-II is allowing space in the system for eight additional circuit "cards" as a buffer for the later inputs. Primarily, the problem is one of time scheduling and increased costs. The present system (to be delivered in December) will, at best, have very limited use. The design based on aerodynamic studies will have to be altered to fit the results of the flight test investigation, even for the rigid body considerations. To progress further, some estimate of bending will have to be introduced, circuits designed, then fabricated and checked, retested in flight test, and optimized. An orderly point to point program must be pursued and will be greatly time consuming. H-II gave no word of encouragement in accomplishing this in the time period from first flight in May to operational capability in January.

4. AUTOPILOT: As with the SAS, the design of the autopilot seems unsatisfactory with present data inputs. The recent change to include alternate heading information to the autopilot in case of INS failure offers a large increase in utilization capability. One big advantage is that this change allows testing of the autopilot even with the INS removed from the aircraft. The requirement for the AP to compensate for the yawing moment with engine flame-out has spotlighted other areas that may cause concern. LAC has expressed the opinion that four degrees of sideslip may induce flame-out. Since this is basically an inlist problem, there may be a similar problem with large changes in angle of attack. When one engine is lost at max speed, a nose down pitch change of approximately 17 degrees is required

to maintain Mach 3.2. The rate of change required has not been determined. If this rate is rapid enough to impose severe $\ddot{\gamma}$ on the aircraft, additional fuel feed and/or lubrication problems may be encountered on the good engine.

5. FAIL-SAFE CONCEPT: The need for artificial systems to provide satisfactory flying characteristics has been adequately stressed in redundant and triple circuits of the stability augmentation system. The dual pickups for lateral stability and triple channels for pitch and yaw are all independent of each other and provide for additional inputs to the control surface actuators in case of single circuit failure. It may be, however, that this concept has not been carried completely through the system. All inputs to the multiple channels come from a single source: the pitot-static tube. Although failure of the pitot tube is not common, it is not without precedent. The need for an alternate source should be investigated.

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6. RECOMMENDATIONS: It is recommended that Lockheed be requested to investigate and/or reevaluate the following:

- a. The need for equivalent airspeed as opposed to calibrated airspeed for the pilot and, hence, air data computer.
- b. The possible loss of engine due to rapid pitch changes with loss of one engine and/or large changes in angle of attack in turns.
- c. The possible need for a redundant pitot-static source.

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